ORIGINALE ARCHIVIO

CARLO GAVAZZI SPACE SpA	**AMS02-PDS**

Tipo Doc.: *Doc. Type:*	REPORT				N° DRD: *DRD N°:*	DEL 105	
N° Doc.: *Doc. N°:*	**PDS-RP-CGS-120**	Ediz.: *Issue:* **1**		Data: *Date:* **SEPT 2009**		Pagina *Page* **1**	Di *Of* **29**
Titolo : *Title :*	PDS-PFM THERMAL VACUUM TEST REPORT						

	Nome & Funzione *Name & Function*	Firma *Signature*	Data *Date*
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REGISTRAZIONE DELLE MODIFICHE / *CHANGE RECORD*			
EDIZIONE *ISSUE*	DATA *DATE*	AUTORIZZAZIONE *CHANGE AUTHORITY*	OGGETTO DELLA MODIFICA E SEZIONI AFFETTE *REASON FOR CHANGE AND AFFECTED SECTIONS*
1	SEPT 2009		First Issue

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1. SCOPE

This document constitutes the test report for the thermal vacuum qualification test for the AMS-02 Power Distribution System Flight Model (PDS-PFM)

The document collects the test data, the instrumentation and setup information, the PVS collection and the step by step signed procedure; conclusions on the test results and conduction are eventually drawn.

2. DOCUMENTS

2.1 APPLICABLE DOCUMENTS

AD #	Doc Number	Issue	Date	Rev	Title
1	**AMS-RQ-CGS-002**	1	April 2007		POWER DISTRIBUTION SYSTEM (PDS) SPECIFICATIONS
2	**AMSCD-PL-CGS-001**	1	04/02/2008		AMS02 PA Plan
3	**PDS-TN-CGS-011**	1	28/03/2008		PDS FM THERMAL ANALYSIS REPORT
4	**PDS-IC-CGS-001**	2	08/06/2009		PDS FM electrical/functional, mechanical ICD
5	**PDS-PL-CGS-003**	1	11/05/2009		AMS02 PDS DESIGN DEVELOPMENT AND QUALIFICATION PLAN
6	**PDS-PR-CGS-012**	2	*16/07/2009*		PDS-PFM THERMAL VACUUM TEST PROCEDURE

2.2 REFERENCE DOCUMENTS

RD #	Doc Number	Issue	Date	Rev	Title
1	**ECSS-E-10-03A**	1	15/02/2002	/	Space engineering - testing

3. ACRONYMS

C.I.	Configuration Item. Also called Part Number (P/N)
CGS	Carlo Gavazzi Space
NA	Not Applicable
P/N	Part Number. Also called Configuration Item C.I.
PA	Product Assurance
PVS	Procedure Variation Sheet
QA	Quality Assurance
S/N	Serial Number
UUT	Unit Under Test
PDS	Power Distribution System
IF	Interface
TVC	Thermal Vacuum Chamber

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4. PARTICIPANTS REQUIRED

4.1 GENERAL

All tests will be performed under QA surveillance in accordance with, and following detailed procedure of applicable PA Plan. Start of the Test shall be notified to Prime Contractor and/or Customer as applicable.

4.2 RESPONSIBILITY

The technical responsibility for testing and test results is up to the Engineering department.

QA is responsible for ensuring that all the agreed procedures are carefully observed, that test equipment and instrumentation used during testing is calibrated and within validity date: that the test data sheets are recorded in the Test Report and signed by the operators and QA witnesses, that all non conforming condition and test results are properly documented and notified to the Prime Contractor, and that all requirements of applicable PA Plan, specification and Statement of Work pertaining to the acceptance tests, are fully satisfied.

4.3 QA WITNESS OF TEST AND SIGN-OFF

QA inspector, or its delegate, shall witness the tests described in this procedure in accordance to the requirement specified in the applicable PA Plans.

4.4 NON CONFORMANCE AND FAILURES

Any malfunction/defect which occurres during the test will be processed along the Non Conformance Procedure described in the applicable PA Plans.

4.5 CALIBRATION REQUIREMENTS

All instruments used for testing shall be calibrated.

Evidence of certification shall be provided by a label attached to the instruments itself, showing the calibration date, the expiring date and the signature of the operator.

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5. TEST ARTICLE

The test article consists of:

MODEL	ITEM	Drawing Number/Part Number	S/N	NOTES
PFM	PDS	10-AMS02PDS-000.00	FM01	-

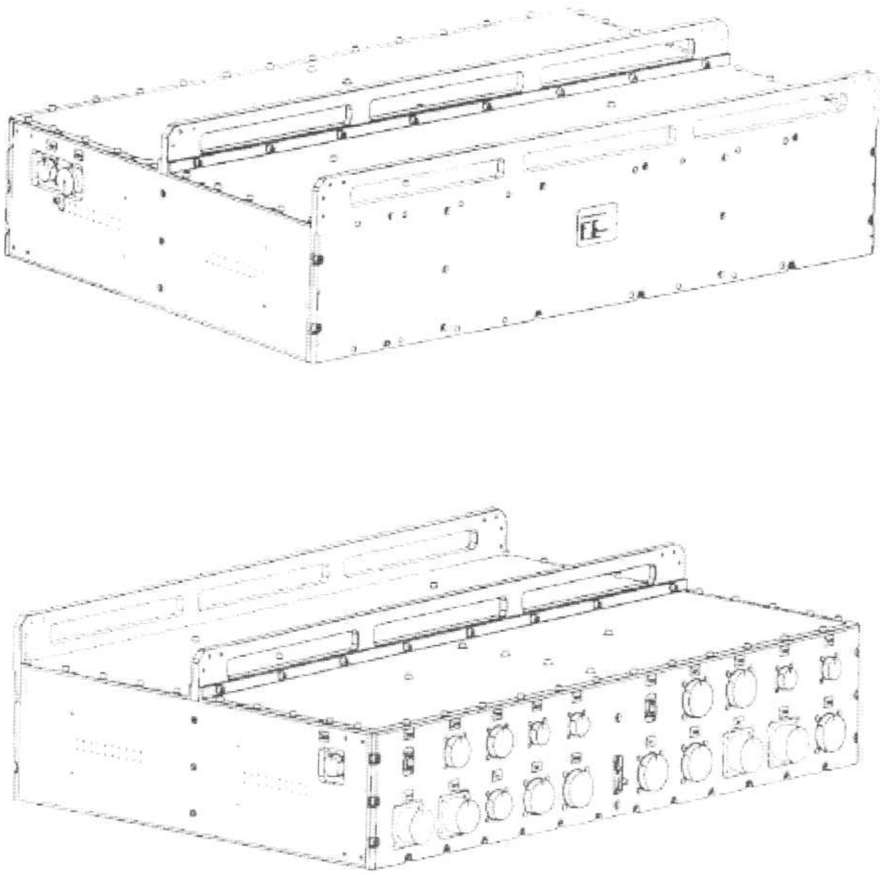

Fig 5-1 - PDS

Before starting the test, the S/N of the test article to be tested shall be recorded on the step-by-step procedure sheets under the table cell "UNIT UNDER TEST".

6. TEST CONFIGURATION

6.1 FACILITY AND TEST SETUP DESCRIPTION

The main aim of this test is to prove the capability of the PDS to meet design requirements under vacuum conditions and during repeated thermal cycling between operative and non operative temperature ranges.

The thermal vacuum test shall be performed at the Università di Perugia S.E.R.M.S. facilities in Terni (Italy). The vacuum chamber available at S.E.R.M.S. laboratory is shown in the picture below:

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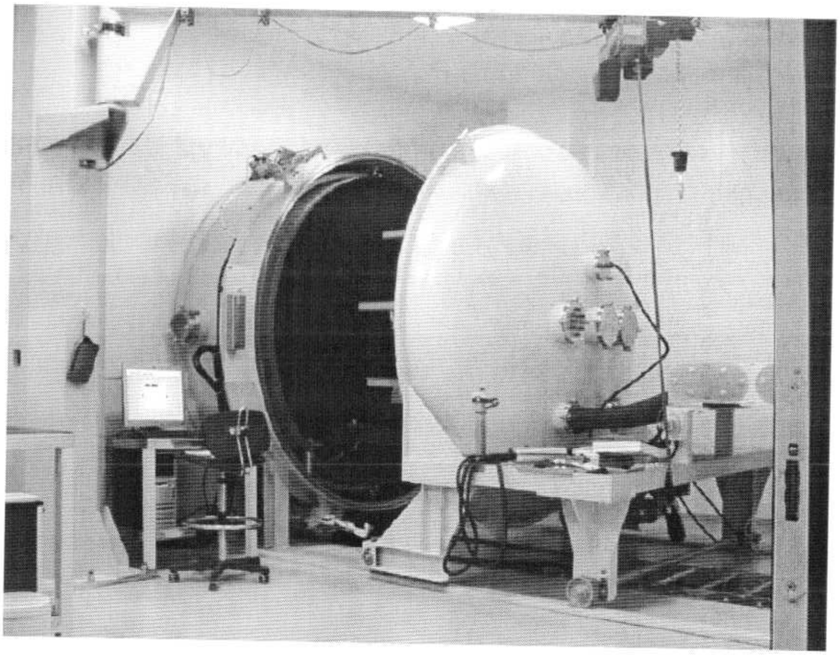

Fig 6-1 - SERMS thermal vacuum chamber

The thermal vacuum chamber (TVC) is located in a clean room (class 100000) and has a cylindrical shape with 3 cold plates on one of the base of the cylinder. Here are some of the most relevant technical data:

- Diameter of the inner cylinder (shroud): 2.100 mm;
- Length of the cylinder: 2.100 mm;
- Minimum pressure: $5x10^{-5}$ mbar (nominal value); registered value during commissioning (chamber without any test item inside): $3x10^{-7}$ mbar;
- Sliding door with three plates (cold plates) fixed on the inner side furnished of M5 holes to fix the test item;
- Dimension of the cold plates:
  - Lower cold plate mm 500 x 1820
  - Middle cold plate mm 500 x 1970
  - Upper cold plate mm 500 x 1550
- Temperature range for the shroud: -70 ÷ +125 °C;
- Temperature range for the cold plates: -70 ÷ +125 °C;
- Average temperature gradient 1°C/min (in the range -20 ÷ +50 °C for the cold plates and in the whole range for the shroud).

The following figure shows the 3 cold-plates with their main dimensions.

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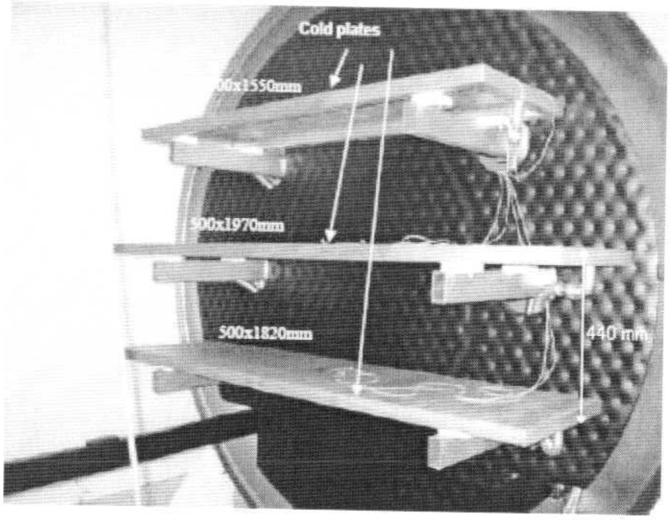

Fig 6-2 - SERMS thermal vacuum chamber base-plate

The PDS during the test shall be positioned on the higher base-plate.

Because of PDS main dimensions (shown in the picture below) and a different pattern of interface holes, a interface base-plate is needed in order to connect the PDS on the thermal vacuum chamber base-plate during the test. This interface plate shall follow the PDS during the whole qualification campaign (functional test on air, vibration test and thermal vacuum test).

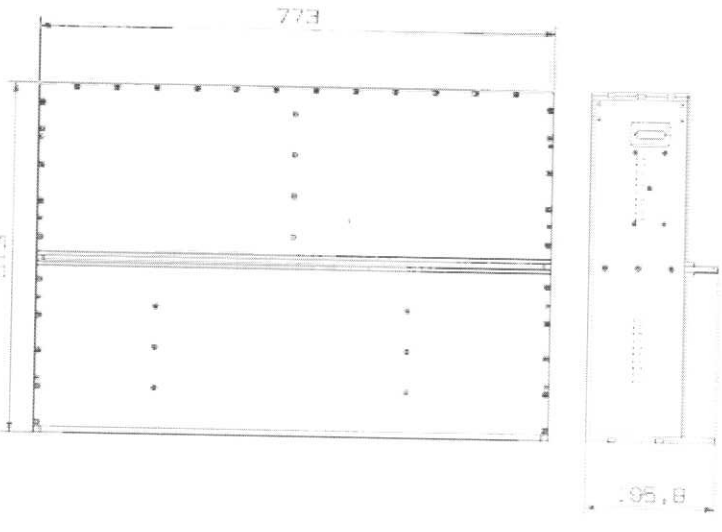

Fig 6-3 - PDS main dimensions

The IF plate has a holes pattern that can be used to fix it on the thermal vacuum chamber base-plate using M4[1] screws provided facility.
Since interaction of this holes pattern with the one used for the connection between PDS baseplate and IF plate, only 29 holes are suitable for fixing I/F plate to thermal vacuum chamber base-plate.
The figure below shows the complete holes pattern of I/F plate. Not usable holes are marked with a red cross.
A thermal filler supplied by the facility will be used between IF plate and TVC baseplate.

[1] Screws shall not be tightened in the IF plate for more than 5mm.

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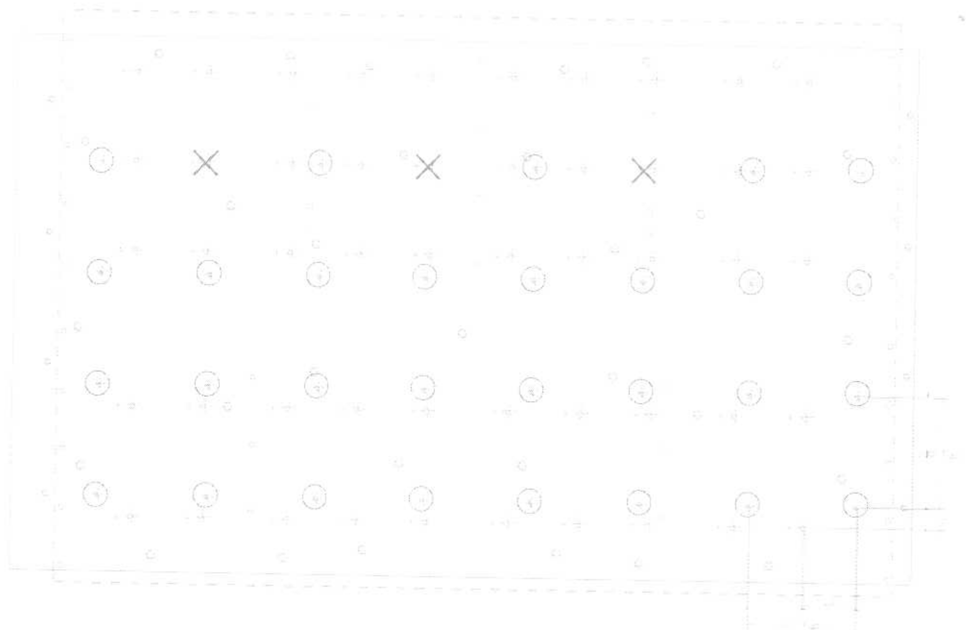

Fig 6-4 - IF plate - holes for connection to TVC base-plate

Concerning the connection of IF plate to PDS, the same holes pattern for flight connection with the radiator (50 holes) shall be used, in order to simulate as much as possible the flight condition. The holes pattern is shown in the figure below:

Fig 6-5 - IF plate holes for PDS connection

In order to have a good thermal conductance between the PDS and the interface plate a thermal filler (CHO-Therm 1671 – P/N 61-015-1721-1671) is needed (according to 52-AMS02GSE-000.00)
Also between the IF plate and the TVC coldplate the thermal filler (provided by the facility) has to be installed.

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As described in the previous pictures the width of PDS exceed the dimension of the vacuum chamber base-plate, so the PDS with the interface base-plate shall run out the vacuum chamber base-plate as shown in the following sketch:

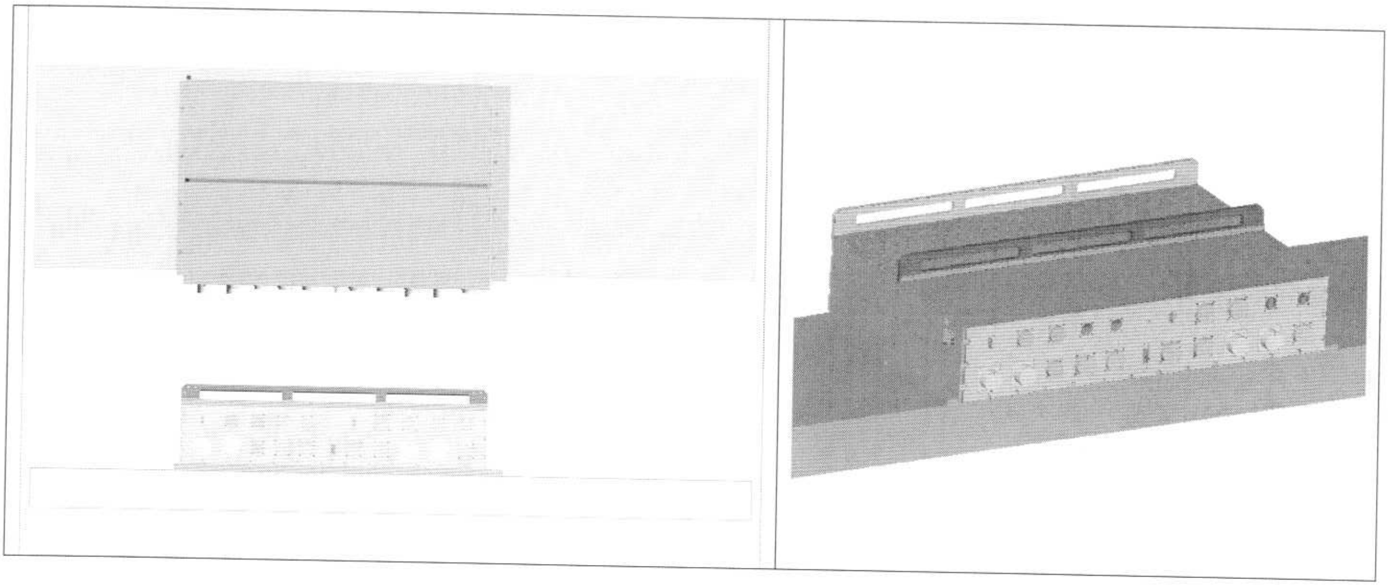

Fig 6-6 - PDS on the vacuum chamber baseplate

As shown the mainly dissipative side of the PDS (the board side in which all the electronic boards are located) is well sunk at the vacuum chamber base-plate.
The part that is not sunk is a small surface of the connector side, where only a very low amount of power is dissipated. With this configuration also all the wiring are more easily connected to the flanges of the thermal vacuum chamber.

In order to avoid radiative coupling to the shroud of the chamber, PDS external surface (except for the base) shall be covered by MLI (provided by the facility).

6.2 PDS THERMAL REFERENCE POINT DEFINITION

According to [AD1] the baseplate of the PDS has been chosen as thermal reference point (TRP). See the following chapter for TRP temperature monitor.

6.3 SENSORS DESCRIPTION

PDS is internally equipped with two temperature sensors located on the two internal front midwall, as highlighted with a red circle in Fig 6-7.
The two internal sensors are qualified thermistors (see details in the following table).

Description	P/N	Proc.Spec.	Supplier
2KΩ @ 25°C THERMISTOR	526-31AN07-202	ACCORDING TO ESCC 4006/001-07 LEVEL B	HONEYWELL FENWAL ELECTRONICS-USA

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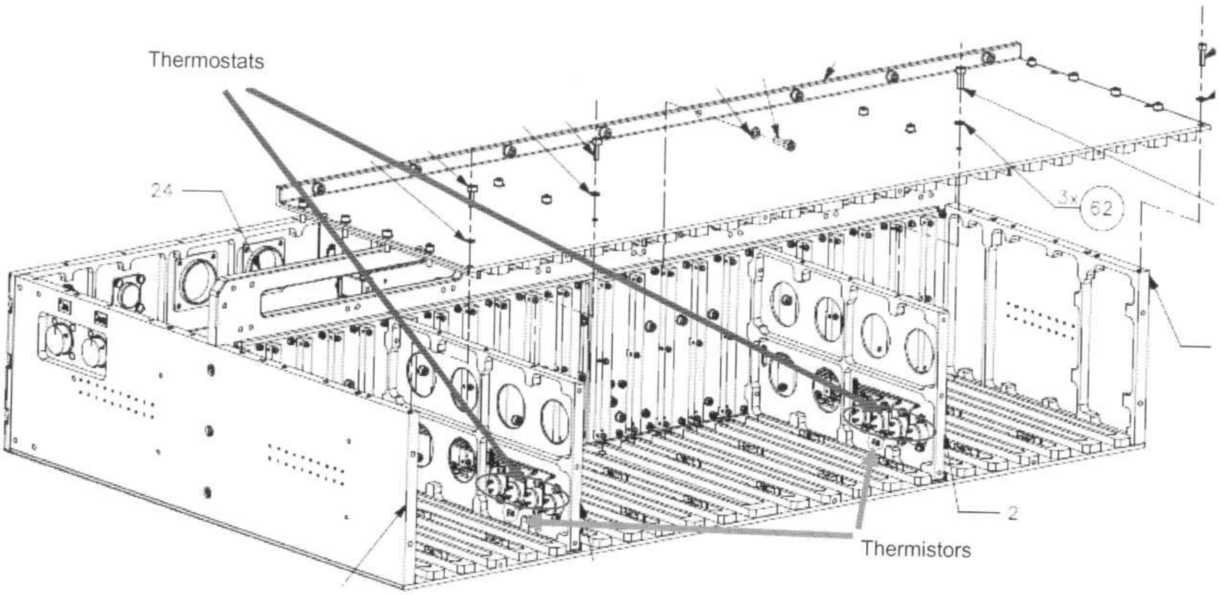

Fig 6-7 - Internal sensors and thermostats position

Additional external sensors (PT100 provided by the facility) on PDS shall be positioned as shown on the following figure: a total of 25 external sensors is foreseen for PDS temperature monitoring.

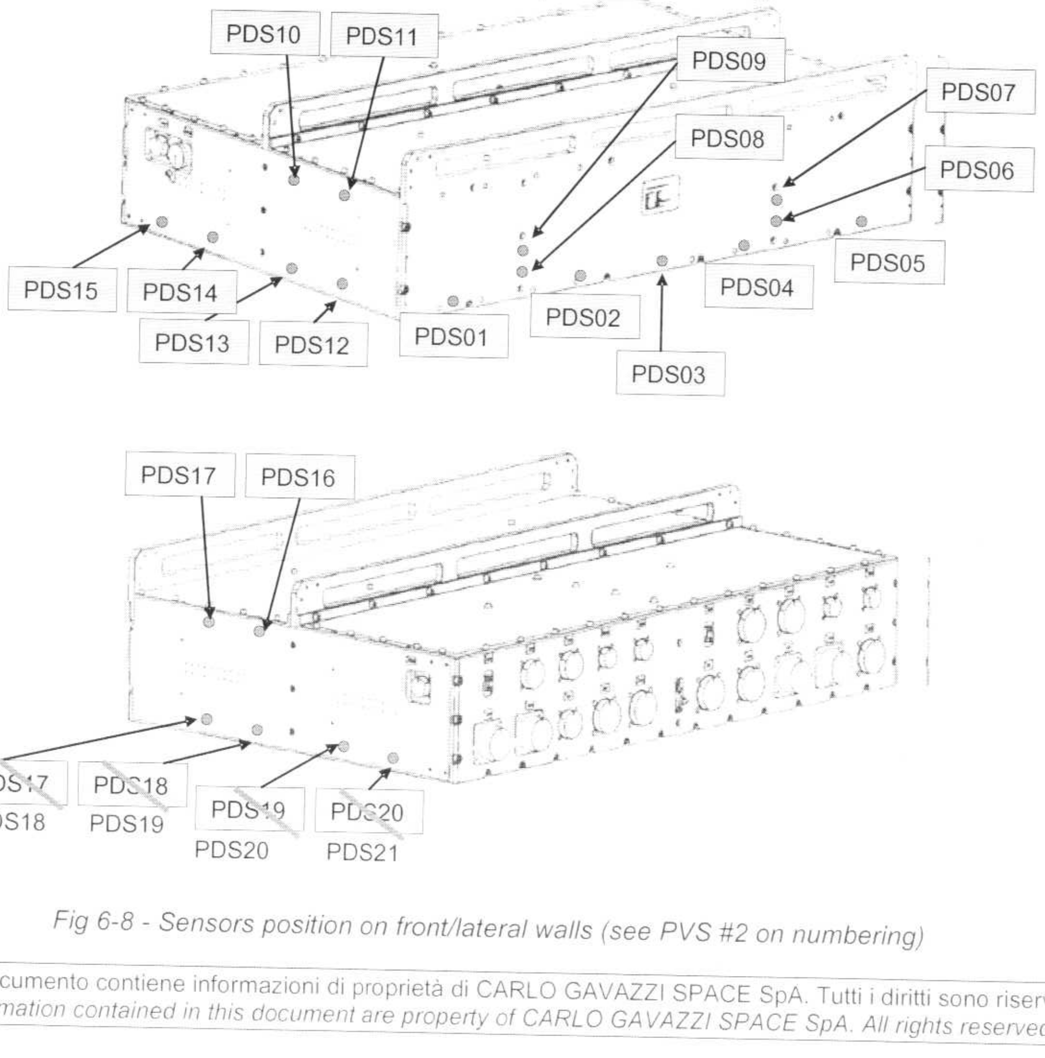

Fig 6-8 - Sensors position on front/lateral walls (see PVS #2 on numbering)

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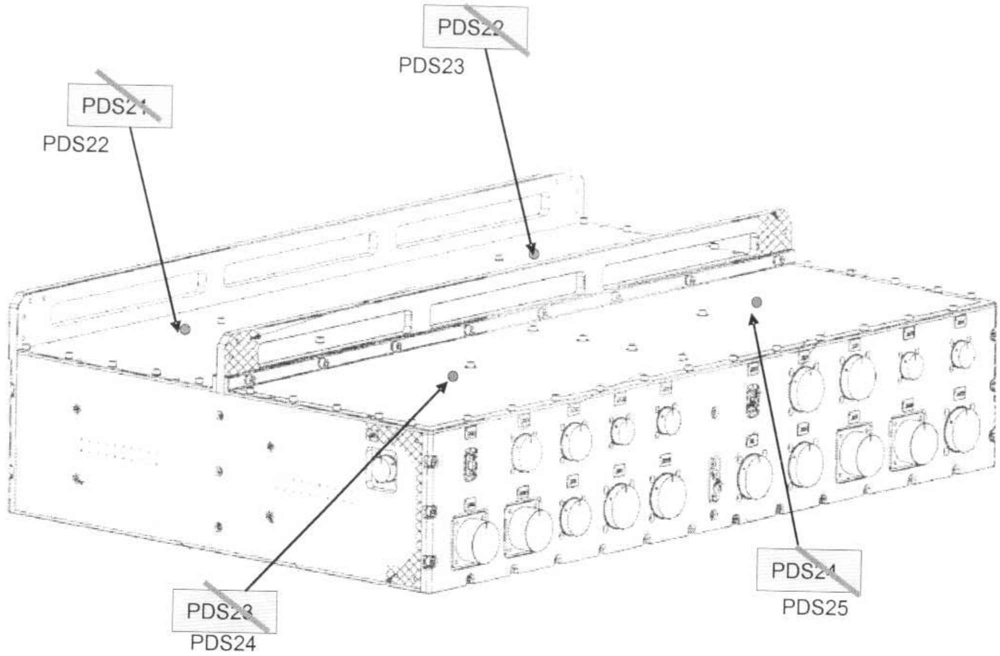

Fig 6-9 - Sensors position on top cover (see PVS #2 on numbering)

Since no sensors can be positioned directly on the baseplate (because of the geometry and the connections of the baseplate itself), sensors named PDS06 (BUS B) and PDS08 (BUS A) are chosen for TRP monitoring. Redundancy for these sensors is given by additional sensors PDS07 and PDS09.

Other sensors shall be positioned on the interface plate in order to measure the temperature impedance given by the contact connection between PDS baseplate, and IF plate.
This interface is very similar to the flight one, and shall be useful to evaluate the thermal connection between PDS and the AMS-02 wake radiator. The following figure shows the position of these additional sensors.

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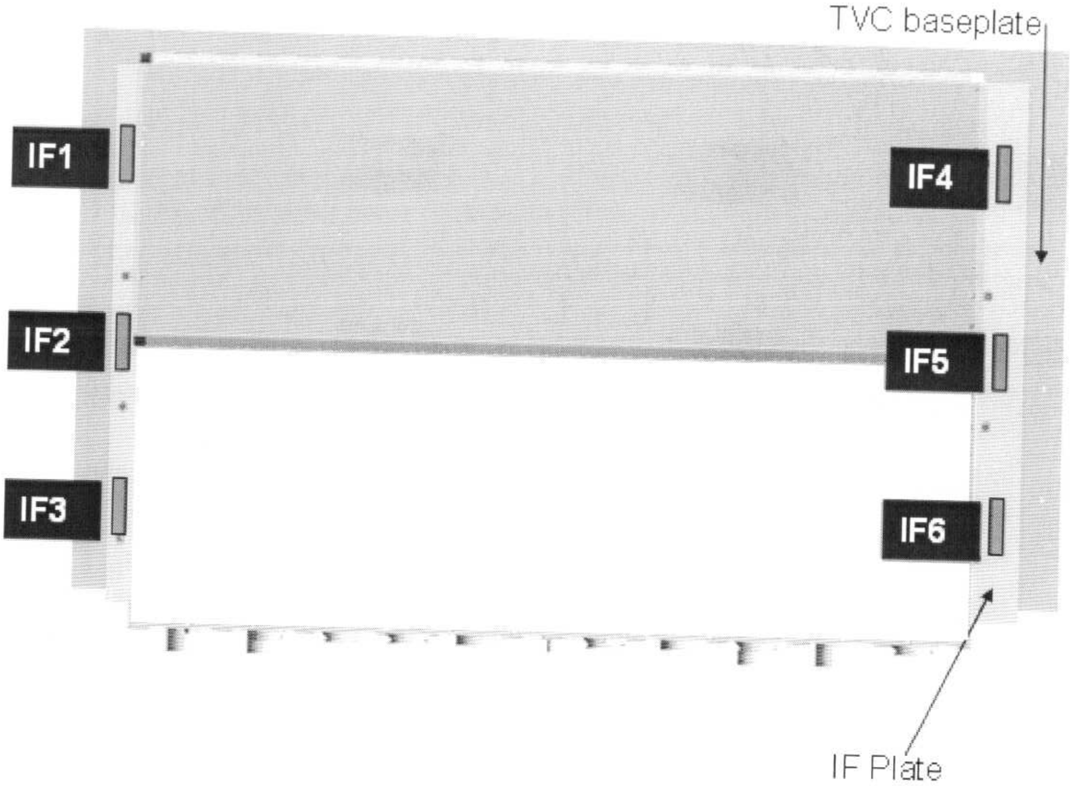

Fig 6-10 - External IF plate sensors position

Both external and IF plate sensors shall be fixed on the UUT using kapton tape, and removed after the test.

6.4 THERMOSTATS DESCRIPTION

PDS is equipped with internal thermostats, positioned on the two internal midwall (just above the above described thermistors – see Fig 6-7). The thermostats are supplied by Honeywell and their main features are summarized in the following table:

Tab 6-1 - PDS thermostats description

Function	P/N	Quantity	Type	Nominal set point		Tolerance on set points
PDS interlock	G311P641/03706S-17B-06/3/3/5	8	Close On Rise	-21.1°C	-27.2°C	±1.7°C

These thermostats avoid the PDS to be operative at a temperature lower than the non operative one.

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6.5 THERMAL TEST DESCRIPTION

Operative/non operative temperature ranges are described in AD4, and summarized in the following paragraphs.

6.5.1 HOT CASE

6.5.1.1 HOT CASE OPERATIVE

PDS shall be tested in a hot operative environment, supplied at 120V and simulating the nominal power operation mode. During the full functional test the whole range of power supply shall be tested (from 113V to 126V).
According to AD4 the TRP temperature in this phase shall be kept at 53°C, i.e. 5°C above the maximum design temperature (48°C).
Both Bus (A and B) shall be tested.

6.5.1.2 HOT CASE NON OPERATIVE (STORAGE)

According to AD4 hot storage temperature (PDS completely switched off) is set at 80°C.

6.5.2 COLD CASE

6.5.2.1 COLD CASE OPERATIVE

PDS shall be tested in a cold operative environment, supplied at 120V and simulating the nominal power operation mode.. During the full functional test the whole range of power supply shall be tested (from 113V to 126V).
According to AD4 minimum operative temperature is -25°C. At this temperature the thermal interlock thermostats status (open or closed) depends on the previouse temperature history: it maybe needed an ad hoc temperature correction of the chamber to force the thermal interlock to switch on .
Both Bus (A and B) shall be tested.

6.5.2.2 COLD CASE NON OPERATIVE (STORAGE)

According to AD4 cold storage temperature (PDS completely switched off) is set at -40°C.

6.5.3 FUNCTIONAL TESTS

A complete series of functional test shall be performed on the first hot and cold operative plateaus, to assure the unit to be capable of perform all functional test on the worst hot and cold temperature.

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6.5.4 THERMAL CYCLING DESCRIPTION

In order to verify the PDS capability of working in the design thermal ranges provided in [AD4], the following cycles profile shall be used:

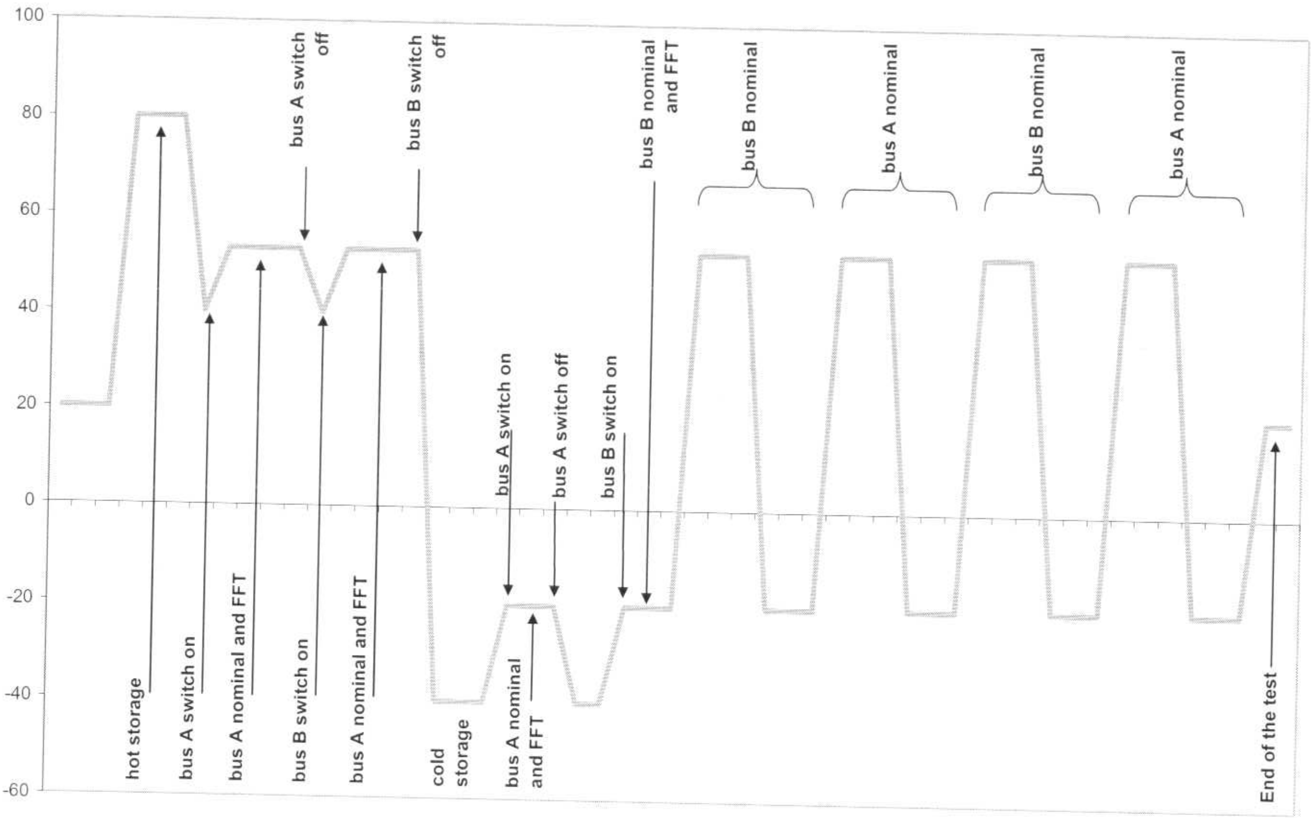

Fig 6-11 - Thermal vacuum test temperature profile

Where the indicated temperature are measured on the TRP and defined as follows:

Hot storage	+80°C
Hot operative	+53°C
Cold storage	-40°C
Cold operative	-25°C

Before and after the Thermal Vacuum test, a full functional test shall be performed at ambient temperature.

The test shall proceed as follow:

- Hot storage temperature – the unit is switched off;
- Hot operative temperature 1st cycle:
  - Switch on sequence of PDS bus A;
  - Load PDS in nominal configuration on bus A (supplied at 120V) until stabilization and wait for 2 hours after stabilization;
  - Full functional test of PDS bus A;
  - Switch off of PDS bus A;
  - Switch on sequence of PDS bus B;
  - Load PDS in nominal configuration on bus B (supplied at 120V) until stabilization and wait for 2 hours after stabilization;
  - Full functional test of PDS bus B;

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- Switch off of PDS bus B;
- Cold storage temperature – the unit is switched off.
- Cold operative temperature 1st cycle:
  - Switch on sequence of PDS bus A (@-25°C with thermostats bypass);
  - Switch off
  - Switch on sequence of PDS bus A (without therm. Bypass to check thermostats working points)
  - Load PDS in nominal configuration on bus A (supplied at 120V) until stabilization and wait for 2 hours after stabilization;
  - Full functional test of PDS bus A;
  - Switch off of PDS bus A;
  - Switch on sequence of PDS bus B (@-25°C with thermostats bypass);
  - Switch off
  - Switch on sequence of PDS bus B (without therm. Bypass to check thermostats working points)
  - Load PDS in nominal configuration on bus B (supplied at 120V) until stabilization and wait for 2 hours after stabilization;
  - Full functional test of PDS bus B;
  - Switch off of PDS bus B;
- Hot/cold operative temperature 2nd cycle:
  - Hot operative temperature, PDS bus B step 4.0;
  - Cold operative temperature, PDS bus B step 4.0;
- Hot/cold operative temperature 3rd cycle:
  - Hot operative temperature, PDS bus A step 4.0;
  - Cold operative temperature, PDS bus A step 4.0;
- Hot/cold operative temperature 4th cycle:
  - Hot operative temperature, PDS bus B step 4.0;
  - Cold operative temperature, PDS bus B step 4.0;
- Hot/cold operative temperature 5th cycle:
  - Hot operative temperature, PDS bus A step 4.0;
  - Cold operative temperature, PDS bus A step 4.0;

During the test both the temperature set points of the thermal vacuum chamber (baseplate and shroud) shall be manually set in order to obtain the desired temperature on the TRP. Since the position of the two sensors and the typical PDS power distribution (when bus A is running bus B is switched off, and vice versa) the difference between the two sensors could be relevant. The TRP sensors of the working part of PDS shall be used as reference.
An indicative suggestion for the hot case is to set the chamber/shroud set point temperature at a temperature 3-4°C colder than the desired on TRP when PDS is fully operative.

During the rising from the cold storage temperature to the cold operating temperature the switch on phase of the PDS is controlled by internal thermostats.
Since the minimum cold operative temperature is exactly in the middle of the thermostats operating range, the cold operating temperature shall be set at the minimum temperature on that the thermostats are all closed (and permit the switching on of the unit).
Every temperature condition has to be maintained for 2 hours after stabilization. Stabilization is considered achieved when a variation lower than 1°C/hour is observed on all temperature.

All temperature rising and falling shall be performed at the fastest rate allowable by the TVC performance.

7. TEST CONDITION

- The UUT shall be tested in its defined configuration: it shall properly closed, all electronic boards shall be present and the UUT thermally related interfaces shall be properly simulated;
- Unless otherwise specified, all measurements are to be performed at the following ambient condition:

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- Temperature +25°C +/- 3°C
- Relative Humidity (RH) 30%<RH<60%
- Pressure Ambient
- Cleanliness 100000 class;

- All tests, unless otherwise specified, shall be performed by a suitable laboratory in a proper area. General disposition shall be applied to maximize personnel safety from potential hazards;
- Connectors savers shall be used as applicable to protect the UUT interface connectors;
- Only skilled personnel shall be involved during the test;
- All used instruments shall meet the necessary accuracy and shall not degrade the UUT performances;

7.1 MEASUREMENTS ACCURACY

Unless otherwise specified, all measurements are to be performed at the following accuracy:
- Temperature:
  - tolerance on minimum operative and non operative temperature -3/0 °C
  - tolerance on maximum operative and non operative temperature 0/3 °C

Temperature will be measured with a maximum uncertainty of ±1.5 °C

- Pressure :
  - -0/+5% of tolerance on max specified value for pressure above 1.3 x 10^2 Pa (1Torr)
  - ±25% of tolerance on max specified value for pressure 1.3 10^{-1} to 1.3 10^2 Pa
  - ±80% of tolerance on max specified value for pressure lower than 1.3x10^{-1} Pa (10^{-3} Torr)

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8. SUCCESSFUL CRITERIA

The test shall be considered completely successful when:

- All temperature data (UUT and TVC) and relevant operation (e.g. TVC temperature setting, PDS switch on/off) are registered
- PDS continuously works under the imposed thermal cycles;
- No shutdown due to high temperature on AD590 sensors (that represents the internal thermal protection system) is observed;
- Internal thermostats (Interlock) switch on in the correct temperature range (PDS interlock thermostats are Close On Rise with nominal set point -21.1°C and -27.2°C);
- Full functional test are successful completed before and after thermal vacuum test and during the first hot and cold stabilizations.

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9. INSTRUMENTAL AND TEST EQUIPMENT

The complete list of the instrumentation (if any) used during the tape application shall be recorded in table 7.-1. The list shall be filled during the tape application and reported in the Report.

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N.	EQUIPMENT	MANUFACTURER	P/N	S/N	ACCURACY	NEXT CAL. DATE	REMARKS

See data in annex 1

Tab. 9-1 Instrument list

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10. TEST PROCEDURE VARIATION SHEET

In case that for any reason the test procedure has to be changed, the change shall be described in a Procedure Variation Sheet (PVS) as shown in the next page.

The PVS shall contain:

- Reference to the procedure to be changed
- Reference to the relevant procedure page and paragraph
- Description of the change, possibly in the form was….is…..
- Reason for change
- Technician, QA, Responsible signatures and dates
- Customer signature and date (when required).

Each PVS shall be identified by a reference number provided in sequential order.

All the generated PVS shall be collected in a dedicated section of the Activity Report.

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PROCEDURE VARIATION SHEET ref. N°:

Procedure Ref.:	Page Revised:	Paragraph Revised:

Description of Change:

Reason for Change:

CONCURRENCE

Technician	QA	System Eng.		Customer
Date	Date	Date		Date

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11. PROCEDURE WORKING SHEETS

The step-by-step procedure sheets are provided in the following pages.

11.1 FILLING THE WORKING SHEETS

The following fields of the data sheets:

- UUT DATA
- Measured value

shall be filled during the test performances and shall be part of the Activity Report together with photographs, sketches, etc. that could be useful to document the activity execution/results.

The Remarks field shall be used to provide, where appropriate, reference to NCRs and PVS.

Activity Report reference data shall be added in the relevant field.

Each data sheet (including the attachments) shall be certified by the System Engineer's signature and date.

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12. STEP BY STEP PROCEDURE

This paragraph explains all the procedures that shall be performed on the model.
Each test activity is defined in sequence and task by task, including test levels to be used and measurement recording to be made.

In the sequence procedure is also contained the statement that the test article shall be tested in accordance with the approved procedure to be signed and dated by Test Conductor, Quality Assurance Representative and Customer Representative (where applicable).

Figure below shows the screw ID connecting the I/F Plate to the PDS unit

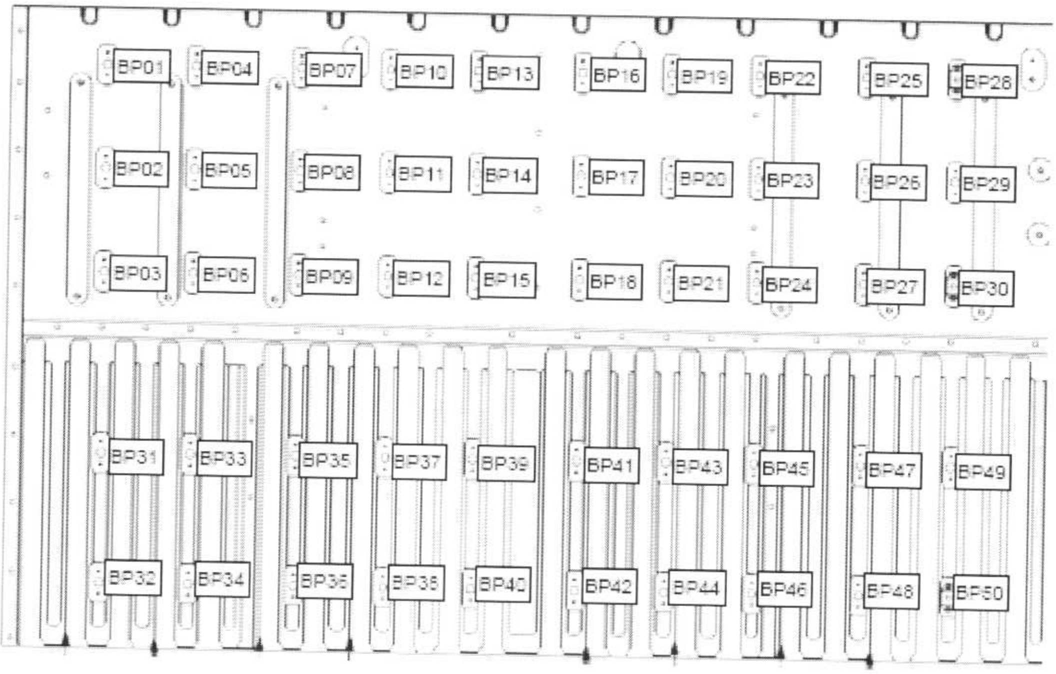

Fig 12-1 - PDS-I/F Plate Screw ID

Final torque of each screw shall be controlled (with reference to the torque reported in the "PDS-PFM vibration test report") and reported in the following table.

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13. CONCLUSIONS

The test has been successfully carried out.

- All temperature data (UUT and TVC) and relevant operation (e.g. TVC temperature setting, PDS switch on/off) have been registered. See Annex 1 for details. An NCR has been raised and promptly solved on a discrepancy on temperature sensor reading, see NCR-PDS-CGS-C-138.
- PDS continuously worked under the imposed thermal cycles, according to the operational phases.
- No shutdown due to high temperature on AD590 sensors (that represents the internal thermal protection system) have been observed; a PB2 shutdown has been observed in extreme conditions, and is reported in the NCR-PDS-CGS-C-139.
- Internal thermostats (Interlock) switch on in the correct temperature range (PDS interlock thermostats are Close On Rise with nominal set point -21.1°C and -27.2°C and ±1.7°C uncertainty); data are recorded in the step by step procedure and reported here for convenience:

Side	Thermostat closing		Thermostat opening	
	Internal thermistor reading	External TRP	Internal thermistor reading	External TRP
SIDE A	-20.4°C	-20.2°C	-28.6°C	-24.9°C
SIDE B	-21.6°C	-21.3°C	-28.6°C	-24.6°C

- Reduced & full functional test are successful completed before and after thermal vacuum test and during the first hot and cold stabilizations; see in particular
    - PDS-RP-CGS-124 iss.1, (reduced functional before TV-Test)
    - PDS-RP-CGS-121 iss.1, (full functional during hot plateau)
    - PDS-RP-CGS-122 iss.1, (full functional during cold plateau)
    - PDS-RP-CGS-125 iss.1, (reduced functional after TV-Test)

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